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Marshall Space Flight Center



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Study of Second Breakdown in Power Transistors Using Infrared Techniques

A program was undertaken to study the potentially destructive phenomenon of second breakdown in bipolar power transistors. The experimental test plan consisted of measuring and plotting the infrared radiation emitted from the surface of a power transistor biased (both forward and reverse) at varying current levels and at the second breakdown point. The experimental data obtained from the plotted thermal profiles indicate that infrared radiation can be used to pinpoint localized temperature buildup which would eventually result in second breakdown. The absolute power of the radiation emitted from the hotspot was found to be a direct indication of the voltage level at which second breakdown occurs.

Test measurements were performed on 200 power transistors energized at varying power levels ranging from the normal rated value upward until second breakdown took place. From the experimental results, the following deductions were made: (1) When energized within their normal stress limit, some power transistors showed a hot spot in some region of the chip, while other transistors exhibiting the same electrical response did not show any hot spots. (2) Those transistors exhibiting initial hot spots developed second breakdown at a voltage level lower than those not exhibiting initial hot spots. (3) Generally, second breakdown "punchthrough" took place at the exact location where the initial hot spot was detected in the thermal map of the unit. (4) Location of the hot spot was found to vary not only from transistor to transistor, but also according to whether the same transistor was operating in the forward bias or in the reverse bias mode.

These deductions lead to the conclusion that infrared thermal maps can pinpoint the exact location where second breakdown will take place long before the phenomenon actually happens, and consequently before any physical damage develops at the hot spot. Subsequent analysis of the crystal structure at that point can lead to the cause of the faulty condition.

The significant advantages of the infrared technique are: No physical contact is required; thermal profiles can be plotted at high scan rates, which make it possible to avoid thermal runaway; and power transistors can be tested and screened for possible defects without stressing them beyond the normal rating.

Note:

Requests for further information may be directed to:

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